Cambridge Institute for Manufacturing (IFM) Innovative Manufacturing Research Centre

Key Data	
Time Period	**10 Years total** Phase 1 (2001-2006); Phase 2 (2006-2011)
Total Value of EPSRC Grant	**£12.9m total** Phase 1 £5.5m; Phase 2 £7.4m
Other Funding *(Direct leverage of additional research funding specific to IMRC)*	**£12.1m total** (94% of EPSRC funding) • 70% UK private sector (£8.5m) • 14% UK public sector (£1.7m) • 8% Overseas (£0.9m) • 8% Charity (£1.0m)
Projects	86 projects funded to date Average size: £150k (EPSRC funding); £291k (All funding)
Current Staff	29 staff funded by IMRC grant
PhD Students	36 PhDs completed to date + 80 current PhD students *(funded by IMRC grant or supervised by staff involved in IMRC)*
IMRC journal publications	267
Patents granted	3
Key Sectors of Focus	Industrial Photonics, Management and Policy
Current Research Themes / Specialisms (Phase 2)	• Industrial Photonics • Technology Management • Emerging Industries • Strategy and Performance • Economics and Policy
Examples of key economic impacts	**1. Supporting business growth –** helping a company breakthrough into a new market and establish a market leading position in the growing high power fibre laser sector. Supporting turnover of £14m, and employment of 210 people in Southampton. **2. Commercialisation of research which has the potential to catalyse new product development and innovation across a range of business sectors** – development of a new laser assisted cold spray metal deposition process 3. **Helping policymakers and private sector R&D managers to develop a strategic framework for R&D activities –** through use of a technology roadmapping management tool. The IfM has undertaken over 200 roadmapping projects, and trained over 750 people to use the tools since 2005.
Key value added aspects demonstrated by the IMRC	• Institutional capacity building • Risk-taking • Staff continuity • Responsiveness to industry needs

Overview of the Cambridge Institute for Manufacturing (IfM) IMRC

The Institute for Manufacturing (IfM) is part of the University of Cambridge's Department of Engineering. It comprises over 240 people made up of faculty staff, PhD research students and researchers. Since it was established in 1998, it has promoted a 'modern' approach to manufacturing research integrating engineering, management and economics disciplines.

The IfM also has a commercial training and consultancy arm. IfM Education and Consultancy Services provides a rapid dissemination route for new ideas and approaches developed by researchers at the IfM. Approximately 30 staff are based in this unit to engage directly with industry, government and other agencies via consultancy, executive training and other events. Their engagements help to both inform and disseminate IfM research.

The IfM research strategy is structured around two research themes which sub-divide into eight subject areas of research as follows:

Theme 1: Next Generation Production Processes:

- **Industrial Photonics –** Pioneering industrial laser systems for a range of novel applications, including high performance and high-efficiency laser sources, advanced fabrication technologies and process modelling of new manufacturing processes.
- **Production Processes –** Innovative production technologies with an emphasis on commercial priorities and the transfer of technology into industry.

Theme 2: Management of Manufacturing and Technology:

- **Technology Management** – Technology-related decisions across the spectrum of business activities; providing comprehensive support to managers, based on an integrated understanding of science, engineering and business management.
- **Strategy and Performance** – Understanding and improving the way strategic choices are made, plans are developed and implemented, and performance is measured and achieved.
- **Economics and Policy** – Economic, technology and political trends likely to influence the business environment; understanding industrial policy and appropriate intervention mechanisms to support innovation and economic growth.
- **Distributed Information and Automation** – Intelligent automation technologies to support flexible manufacturing operations and supply networks; technologies and systems enabling automatic identification of manufactured objects throughout the supply chain.
- **International Manufacturing** – Manufacturing in a global context, including international manufacturing and supply networks, supplier selection and management, global alliances and relocation of production facilities.
- **Emerging Industries (Established in 2006/07)** – Understanding the translation of scientific ideas and opportunities into products and services. It aims to go beyond the increasingly well-established approaches to technology transfer, and to understand the creation of substantial new industries and the infrastructure needed to support them. The intention is to provide guidance for industrialists and policymakers seeking to develop the next generation of substantial new industries.

IMRC Research Strategy

The IMRC is an integral part of the IfM and supports most elements of the IfM research strategy (although to varying degrees).

The IMRC Phase 1 Programme initially supported the management element of the IfM research programme (£2.95 million was approved for this). This reflected the type of research projects the IfM had with EPSRC at the time.

In 2003 Dr. Bill O'Neill, who was heavily involved in laser-based photonics at the Liverpool University IMRC, moved to Cambridge University. His IMRC funding for industrial photonics at Liverpool University was transferred to the IfM (£2.6 million). The Liverpool University IMRC folded as Dr O'Neill's research represented the bulk of the programme.

Thus, from 2003 the Phase 1 IMRC programme was split fairly equally in funding terms between industrial photonics and research on the management of manufacturing and technology.

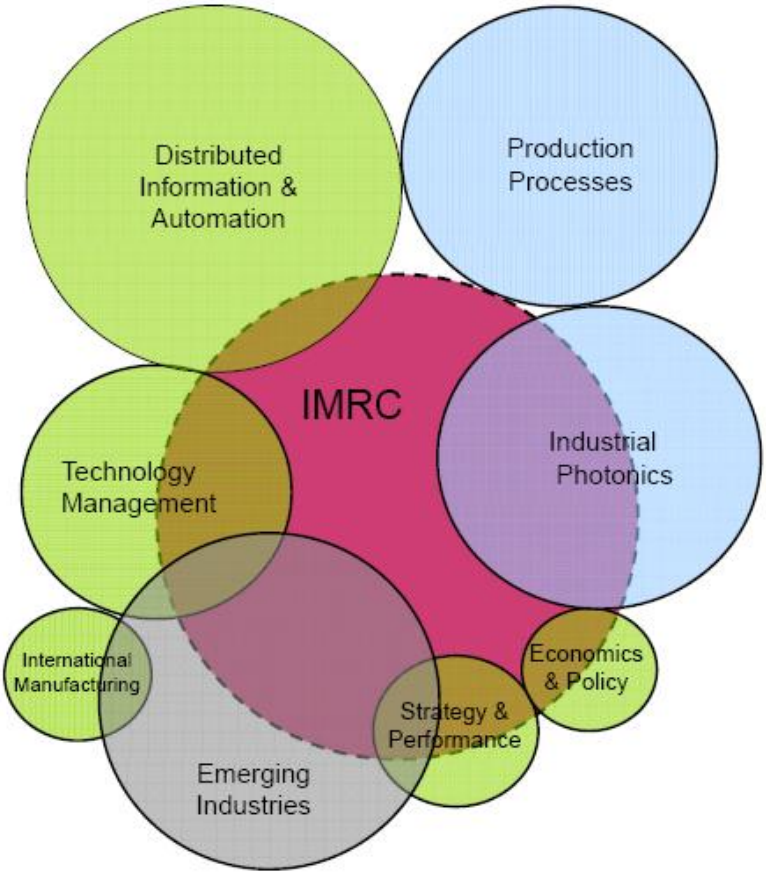
Phase 1 - Theme	Number of Projects	EPSRC Funding (£)	Design	Technology	Management
Industrial Photonics	13	2.6m (47%)	-	100%	-
Management of Manufacturing and Technology	31	2.95m (53%)	-	-	100%
	44	**5.55m**			

The IMRC Phase 2 Programme continues to focus on the same broad areas of research as Phase 1. The main difference is a greater proportion of funding is allocated to management-related research. This reflects the establishment of the Emerging Industries Research Programme in 2006/07. It was decided that a significant proportion of IMRC funding would be used to launch this new, innovative programme of research at the IfM.

Phase 2 – Theme	Number of Projects (To Date)	EPSRC Funding (£) (Budget Allocation)	Design	Technology	Management
Industrial Photonics	11	2.6m (35%)		100%	
Management of Manufacturing and Technology	30	3.85 (65%)			100%
Management / Admin	N/A	1.0m	-	-	-
	41	7.45m			

The diagram below shows the role of the IMRC in underpinning IfM research programmes. The size of the bubbles reflects the level of resources invested across the IfM as a whole in different research areas. The IMRC makes a significant contribution to five of the eight research programmes (Industrial Photonics, Technology Management and Emerging Industries – and to a smaller extent Strategy & Performance and Economics & Policy.

Relationship between IMRC and Cambridge IfM



IMRC funding made it possible for the IfM to launch a major new programme of research into Emerging Industries in 2006/07. In an increasingly global economy, with rapidly increasing rates of technological innovation, it is ever more important to build industries based on innovative science and engineering. Despite an excellent science base the UK has been relatively slow to build new industries based on this foundation. The IfM was keen to address this issue by establishing an innovative programme of research to support the creation of substantial new industries. The aim was to develop a better understanding of the elements and dynamics of emerging industrial systems and to provide guidance for industrialists and policymakers seeking to develop the next generation of substantial new industries. This could not be achieved through funding isolated, individual research projects. There needed to be a programme of research that had sufficient critical mass to enable different facets of the subject area to be investigated. It was IMRC funding which made this possible, with £1.6 m allocated to launching a new multi-faceted research programme in this area.

IMRC Programme Management

Each research area within the IfM is led by a specific member of staff and has its own research strategy. IMRC Phase 2 funding has been allocated between the research areas roughly as set out in the diagram above: some centres receive minimal IMRC funding such as production processes, others receive significant funding such as industrial photonics. The way in which IMRC funding is allocated across IfM research areas is a reflection of the relative priority attached to the research area and the availability of funding from other sources. IMRC funding is directed to high priority research areas where alternative funding opportunities are more limited.

The IMRC Management Committee comprises the IfM Director (Mike Gregory), the IMRC Programme Manager (Paul Herrernan) and a small number of senior academics engaged in the IMRC programme. A formal proposal must be prepared for all IMRC projects. Proposals are reviewed by the management committee which meets on a monthly basis. All proposals are assessed against strategic fit with research strategy, academic merit and industrial relevance.

There is also an IMRC Industrial Advisory Group (IAG) which exists to provide advance and guidance to the IMRC and meets on a quarterly basis. External members of the IAG fulfil a role broadly similar to that of non-executive Directors in a commercial company. All IMRC project proposals in excess of £0.5 million must be referred to the IAG for approval.

Economic Impact Analysis

Funding and Leverage

According to the data provided by the Cambridge IfM for this exercise

- A total of £12.1 million (cash and in-kind contributions) has been provided by partners for IMRC-related research. Thus, for every £1 provided through the IMRC, £0.94 has been contributed by other partners.
- 70% of partner contributions are from private sector companies.
- Key collaborators include Carl Zeiss, 2020 Insights LLP, BOC, Unilever, Yamazaki Mazak UK, and Rolls Royce.

Delivering Human Capital to the Labour Market

Approximately 25 staff / researchers have worked in, but now left, the IMRC. Approximately one third have been recruited to work in industry which represents a significant transfer of skills from academia to industry.

Approximate proportion of former staff/researchers in:	
Academia	59%
Industry	36%
Government	5%

The case studies below illustrate how skills have sometimes been transferred into industry through research staff and students being recruited by partner and related companies:

- **Strategic Technology Roadmapping Case Study:** four key staff contributed to the development of IfM roadmapping methods. Three continue to work for the IfM in senior roles and the fourth is now Chief Executive Officer of the Treffert Group (one of the leading providers of coating systems for the laminate wood flooring industry).

Research Impact

Four projects have been selected by DTZ in conjunction with the IMRC and EPSRC to illustrate the economic impact of research funded through the Cambridge IfM IMRC. These case studies have been selected on the basis of the agreed shortlisting criteria, as follows:

- Demonstrates a range of types of economic impact as defined by BIS
- Offers convincing evidence of significant tangible impact
- Demonstrates the added value of the IMRC model
- Coverage of the different research themes within the IMRC
- Sector coverage.

Overall, the selection of case studies is typical of the types of work that the IMRC is engaged with, whilst focusing on examples which demonstrate significant impact and added value. The key points relating to case study selection are as follows:

- The **industrial photonics** research programme represents a significant element of the IMRC programme in Phase 1 and Phase 2. Thus, two case studies have been selected from this area.
- Research related to the **Management of Manufacturing and Technology** accounts for the bulk of remaining IMRC spending. Two projects have been selected from the Technology Management research area (which is where significant IMRC funding has been invested) to illustrate this part of the IMRC programme. The two projects have, however, been treated as one case study since it was found that both were based on the same underlying research and there was considerable synergy between them

The cross-cutting **emerging industries programme** is an important part of the Phase 2 IMRC programme. However, the programme was only established in 2006/07 and it took some time to get projects off the ground, so research is not as advanced as in other areas for significant economic impact to have been achieved. Thus, no case studies in this area have been selected. However, the programme is beginning to generate economic impact in a number of ways.

For example, one aspect of the emerging industries programme is using the roadmapping techniques developed through the IMRC programme (and included as a case study in this exercise) to identify the enablers and barriers that occur at the transition points during the emergence of a new industry. It aims to draw lessons from past examples and develop guidelines for organisations seeking to create value from emerging, technology-based industries. One of the researchers involved in this research (Eoin O'Sullivan) spent a period of time **on secondment to BIS (1 day / week to BIS) advising one of its teams on the role of the science base in attracting foreign investment for emerging industries. He also provided a range of other policy assistance to this team which is led by Graham Reade and focuses on the economic impact of research.**

Staff involved in the Emerging Industries programme were also consulted as part of the **Hauser Review on the Current and Future Role of Technology and Innovation Centres in the UK. Hauser visited the Cambridge IfM on 3-4 occasions to meet staff and to collect information which helped to inform the international comparison section of this influential report**.

Overall the case studies are reasonably representative of the types of research which have been funded through the IMRC at the IfM, with the exception of the Emerging Industries programme for the reason set out above.

Case study	BIS Impact Headings	Added Value Aspects	IMRC Research Theme	Sector
Laser Cold Spray – a new means of depositing metallic coatings on a range of materials.	New spin-out company	Staff continuity Risk-taking	Industrial Photonics	Laser Manufacturing
High Brightness Fibre Laser – to support the development of a prototype 1KW 'high brightness' fibre laser.	Improve existing business competitiveness	Risk-taking	Industrial Photonics	Laser Maufacturing

Case study	BIS Impact Headings	Added Value Aspects	IMRC Research Theme	Sector
Technology Roadmapping for Sectoral Foresight - a graphical management tool for technological strategy development.	Improving public policy and services	Responsiveness to industry needs	Technology Management	Cross-Sectoral
Strategic Technology Management Tools – a graphical management tool for technological strategy development.	Improving existing business competitiveness	Responsiveness to industry needs	Technology Management	Cross-Sectoral

Added Value of the IMRC Funding Model

The added value of the IMRC funding model (as evidenced through the economic impact case studies selected) is:

- **Institutional capacity building** – IMRC funding has helped to develop the institutional capacity of the IfM. The block grant has led to more top-down strategy development for research; rather than bottom-up, individual research projects. This is evidenced through the establishment of the Emerging Industries Research Programme. IMRC funding has enabled the establishment of a holistic research programme with sufficient critical mass to enable different facets of the subject area to be investigated. The rationale for this is that greater impact will be achieved from tackling the subject area as a whole rather than through one-off individual projects. It is too early to assess whether this has been achieved but IMRC funding has made it possible.
- **Risk-taking –** it is easier to take informed, calculated risks with IMRC funding than with funding that has to be approved through EPSRC committees. For example, it was a significant risk to invest a large proportion of IMRC funding (£600,000) in developing a high power fibre laser. However, the IMRC had in-depth knowledge of the research area and team and was confident in its capabilities. The risk, which might have been too much for others, has paid off.
- **Staff continuity** - under responsive mode funding, there is a danger that a promising area of research cannot be continued because key staff leave (or are redeployed) before further funding is secured or subsequent proposals relating to the research are not approved. IMRC funding means that a promising area of research can be developed over a period of time. For example, IMRC funding meant that research on a laser assisted cold spray metal deposition process could continue without delay from a previous project, and that key staff with specialist expertise could be retained to work on the project. This was critical to the success of this project. If applications for competitive funding had been necessary, key staff might have been lost or the research might never have gone ahead
- **Speed of response to industry needs –** IMRC funding enables academic researchers to respond to industry requirements more quickly than under responsive mode funding. For example, the research team involved in developing technology roadmapping worked with many companies and organisations because it had the flexibility to respond to needs and requirements as they arose.

Case Study 1: A New Metallic Coating Technology

Key Facts	
Time Period	2006-2009
IMRC Funding	£270,000
Other Funding	N/A
Collaborator(s)	N/A
IMRC Research Theme	Industrial Photonics
Research Output	A new laser cold spray (LCS) metal deposition process which makes it possible to deposit metal onto other types of metals / materials that was not possible in the past.
Pathway to Economic Impact	**EPSRC Integrated Knowledge Centre** **Spin-Out Company** **Licensing Agreement**
Actual Economic Impact	**A spin-out company has been established**. A licensing agreement for the technology is being negotiated. The global paint and coatings market is valued at $90 billion (£58 billion) and expected to rise to $110 billion (£70 billion) by 2013. Even if the LCS process is only relevant to a small proportion of this market, it is clear there is a significant market opportunity for the technology.
Potential Economic Impacts	**Potential to catalyse new product development across a range of sectors**. For example, there are potential applications for titanium coatings in the biomedical, aerospace, automotive, energy and machine tools sectors. There may be similar opportunities for other types of metal coatings. **Reducing UK health costs.** New titanium coated implants for hip replacements could reduce the number of second hip replacement operations. It is estimated that this could save £4.3 million per annum although the scale of cost savings are probably higher as it could also be relevant to other joint procedures.
Sector Focus	Materials coating but potential applications across a multitude of sectors.

Context

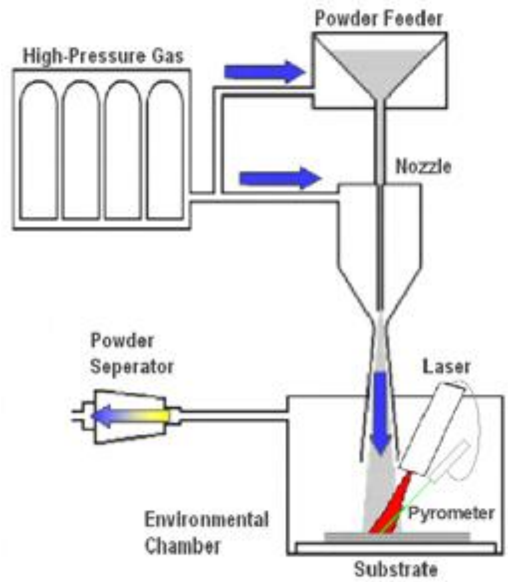
Coatings are applied to a multitude of products – everything from fibre optic cables to the hard disks in computers have a coating applied to them. Metal is used as a coating material in many manufacturing environments. The problem with the current technology is that it is not suitable for depositing one type of metal on to another, or for depositing metal on to non-metallic materials (for example carbon fibre). This is because of the use of heat to achieve bonding and the fact that different materials have different melting points and responses to heat. For example, the melting points for plastic and aluminium are 150^{o}C and 700^{o}C respectively. The challenge for researchers was to find a metal deposition process which did not involve the use of heat.

Research on a cold spray (CS) metal deposition process began before the establishment of the IMRC. It was one of the EPSRC legacy projects transferred into the Liverpool IMRC and subsequently into the Cambridge IfM IMRC, when Dr Bill O'Neill moved to Cambridge in 2003. The 'cold' mechanism of deposition relies on a gas stream accelerating powder particles through a high pressure nozzle gun at very high speed (see diagram overleaf). Achieving such velocities requires a large consumption of hot gas (helium was used in this research) leading to high operating costs because helium is an expensive gas. Industry feedback was that the researchers needed to get operating costs down from the current £8 / minute to around £0.60 per minute, for this process to be viable in a commercial manufacturing environment.

The IMRC Project

IMRC funding represented an opportunity to continue the research and to address the challenge of developing a CS process at reasonable cost. Critically, IMRC funding meant the research could continue without delay and that key staff with specialist expertise could be retained to work on the project. If applications for competitive funding had been necessary, key staff might have been lost or the research might never have gone ahead.

The IMRC project led to the development of a new laser cold spray (LCS) metal deposition process. In LCS, a laser heats the deposition site so it is considerably softened: this allows bonding to occur on impact at velocities around half those needed for cold spray (< 500 ms-1) even when depositing materials such as titanium.



Schematic Diagram of the LCS System

Reducing the need for high velocities means nitrogen can be used instead of helium, reducing gas costs and overall operating costs substantially. This reduction in costs means LCS is viable in many applications for which CS previously proved too costly.

Potential applications for the technology are numerous. In 2007, Cambridge University bid successfully with Cranfield University (and other partners) to EPSRC for funding to establish an Integrated Knowledge Centre (IKC) in Ultra Precision and Structured Surfaces. IKCs promote the early commercialisation of world class research by combining within a single integrated centre the best research with the best business opportunities to accelerate exploitation. A £375,000 grant from the IKC (2009-11) has been awarded to explore commercial applications for the LCS process.

One of the main applications that has been explored is using the LCS process for various types of titanium coatings. The corrosion resistant and biocompatibility properties of titanium mean that there are a number of potential applications for the LCS process in the biomedical field. For example, the ceramic implants used for hip replacements have a limited life which mean many people need to have a second hip replacement operation. Applying a titanium coating to a ceramic implant would extend the life of the implant substantially and reduce the need for second 'replacement' operations. At present, it is not possible to apply a titanium coating to a ceramic object, but the LCS process makes this possible.

Titanium coatings could also have application in the shipbuilding, aerospace and automotive sectors to reduce corrosion. Other potential applications are in the energy and machine tools sectors. For example, coating pipelines with high value corrosion resistant layers to create more durable pipelines and coating machine tools with hard-facing materials to increase production life.

Assessment of Economic Impact

The economic impact of the project can be assessed as follows:

- Formation of a new spin-out company
- Potential to catalyse new product development in other sectors
- Potential to reduce UK health costs

Formation of New Spin-Out Company

The next step is to move the LCS process from the laboratory to the market. A new university spin-out company, Fusion Technologies Ltd, was established six months ago to take forward this opportunity. The business model is to licence the LCS technology. Fusion Technologies Ltd will provide technical support to the licence holder and will use income generated from this and the licence agreement to invest in new R&D activities. The vision is that it will become a R&D business specialising in industrial photonics, generating revenue through the creation of new IP which is subsequently licensed to industry. It is very early days for the business but the plan is to create a substantial business within five years.

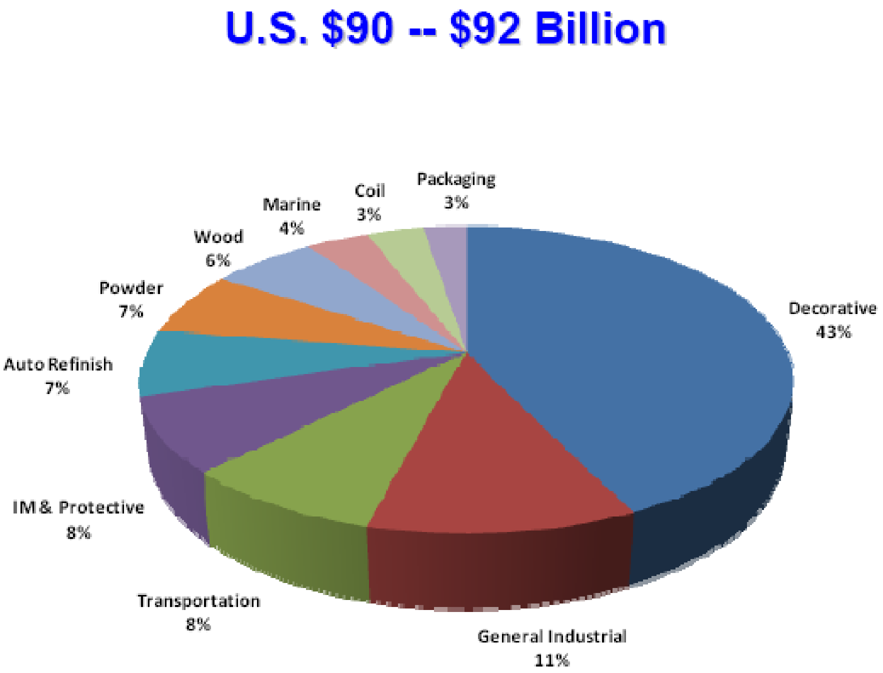
Fusion Technologies Ltd is currently negotiating the terms of a licence agreement with IPG Photonics. IPG Photonics is the leading global manufacturer of high power fibre lasers and is headquartered in the USA. One of its lasers was loaned to the university's industrial photonics centre at the time the research was undertaken and is used in the LCS process.

IPG Photonics says the next step will be to produce a commercial prototype at its production plant in the USA. It has not yet decided whether it will take this forward itself or in conjunction with other partners. It is too early to predict potential revenue streams since this will depend on the applications that emerge for the LCS process, but Joe Dallarosa, Director of Integrated Systems at IPG Photonics comments:

"*There is a high degree of excitement about the commercial opportunities for this technology in sectors such as medical devices, aerospace and transportation*".

The global paint and coatings market is valued at $90 billion and expected to rise to $110 billion by 2013.[1] Even if the LCS process is only relevant to a small proportion of this market, it is clear that there is a significant market opportunity for the technology.

Value and Structure of the Global Paint and Coatings Market[2]



Potential to Lead to New Product Development in Other Sectors

The research represents a breakthrough in metal deposition technology and this could catalyse a range of new products. For example, a next-generation of titanium coated implants for hip replacements. The UK medical devices sector is worth £4.4 billion and employs 47,000 people. Thus, there is potential for the research to generate significant economic impact by helping to grow this market.

Potential to Reduce UK Health Costs

There is potential for new product innovation such as that described above to reduce government expenditure. For example, according to the National Joint Registry there were 72,432 hip replacement procedures completed in 2009, growing by 1% on the previous year. 65,229 were primary procedures and 7,203 were revision surgeries, representing a revision 'burden' of 10%, an increase from 9.2% in 2008[3]. The average cost of a hip replacement is £6,000, the more complex repair operations, with more expensive implants, bone grafts and longer hospital stays, cost between £10,000 and £15,000[4].

If new titanium coated implants for hip replacements reduced the number of replacement hip operations by 10%, the estimated cost saving would be in the region of £4.3 million per annum. Of course, this is an under-estimate since the number of hip replacements is projected to rise, the

[1] Global Paint and Coatings Market Analysis Report 2009-2014, Orr & Boss, http://www.paint.org/pubs/global_analysis.cfm

[2] Global Paint and Coatings Market Analysis Report 2009-2014, Orr & Boss, http://www.paint.org/pubs/global_analysis.cfm

[3] *http://www.njrcentre.org.uk/NjrCentre/LinkClick.aspx?fileticket=QkPI7kk6B2E%3d&tabid=86&mid=523*. A revision is defined as an operation that involves the removal and replacement of one or more components of a joint replacement.

[4] http://www.timesonline.co.uk/tol/life_and_style/health/article6843637.ece

reduction in hip replacement operations could be greater than 10% and there could be savings in other types of joint procedures that have not been taken into account.

Position without IMRC Funding

The research was high-risk with no guarantee of a successful outcome. It was a significant challenge to reduce operating costs to a level which would be viable for commercial operation. It was too far from market for the private sector, hence the need for public intervention.

Consultees

The following people were consulted and reviewed a draft of the case study:

- Dr Bill O'Neill – IMRC, Cambridge IfM
- Joe Dallarosa – Director of Integrated Systems, IPG Photonics

Case Study 2: A New Generation of High Power Fibre Lasers

Key Facts	
Time Period	2004-2007
IMRC Funding	£600,000
Other Funding	£300,000 (In-Kind)
Collaborator(s)	SPI Lasers (part of the TRUMPF Group) based in Southampton
IMRC Research Theme	Industrial Photonics
Research Output	The research project helped SPI Lasers to launch a new range of high power fibre lasers.
Pathway to Economic Impact	**Via Collaborator (s).** SPI Lasers launched a new range of high power fibre lasers (up to 200W) from 2006. The product range was upgraded to up to 400W from 2008. The company is currently working on launching a 1KW commercial product.
Actual Economic Impact	**Supporting business growth**. The research has played a significant role in helping a company which was in difficulty in 2002 due to the downturn in the telecommunications market, to enter a new market and become the No 2 player in the global fibre laser market. Turnover was in excess of £14 million last year and the company now employs around 210 people in Southampton.
Potential Economic Impacts	**Supporting business growth.** The company is confident about its growth prospects and, depending on the health of the global economy, is expecting year-on-year doubling of turnover for the next few years. It is currently seeking new business space in Southampton to respond to this growth.
Sector Focus	Industrial Lasers

Context

The industrial laser industry has grown steadily over the last 40 years. In the early 2000's, the **fibre laser** was developed. The technology came from the work of two academics in fibre amplifiers for the telecommunications industry (Professor Payne at Southampton University and Professor Gaponsev at the Moscow Academy. Both established companies to exploit the technology - SPI Lasers based in Southampton (Payne) and IPG Photonics based initially in Russia, then Germany, and now headquartered in the USA (Gaponsev).

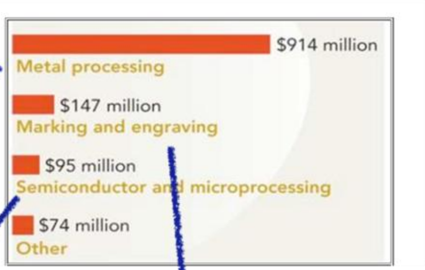
Fibre lasers have many advantages over more traditional laser systems due to their compact design, higher efficiency and longer life. In addition, they are maintenance free, offer rapid installation and as a result have significantly lower costs of ownership.

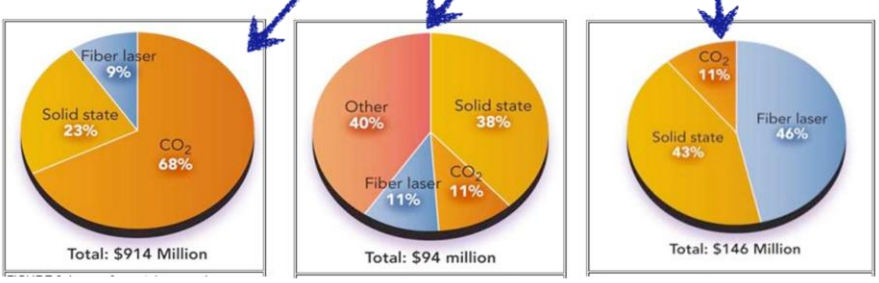
Information from the University of Cambridge (sourced from Industrial Laser Solutions) indicates the global market for fibre lasers was worth $213 million in 2008. The main applications for fibre lasers presently are: metal processing; marking and engraving; and semiconductor and micro-processing.

LASER	2008	2009 EST	% CHANGE	2010 PROJ.	% CHANGE
CO_2	1091	669	-39	723	8
Solid State	394	340	-14	365	7
Fiber	213	169	-21	190	12
Other	60	53	-12	58	9
Total	1758	1231	-30	1336	[illegible]

Table 1. Global industrial laser revenues—$ Million

Source: Industrial Laser Solutions





IfM Centre for Industrial Photonics 6 UNIVERSITY OF CAMBRIDGE

Research by the leading photonics market research group, Strategies Unlimited, says the market for fibre lasers in 2009 was worth $280 million. It also forecasts annual compound growth of 9% in the industrial laser market as a whole to 2014. However, previous market trends would indicate a higher level of growth in the fibre laser market.[5]

There are now many players at the low power end of the fibre laser market but two companies dominate the medium - high power end SPI Lasers is one of these companies (IPG Photonics – the market leader - is the other). The strength of SPI Lasers in this market can, in part, be linked to R&D support provided through the Cambridge IfM IMRC as explained below.

The IMRC Project

SPI Lasers is a spin-out from Southampton University and was established in 2000. Initially, the company intended to target its fibre amplifier technology at the telecommunications industry. The company was successful in raising a substantial amount of venture capital and at one point employed close to 100 people, but then the telecommunications market collapsed and a large proportion of the workforce had to be laid off. The company needed to find a new market for its technology and in 2002, a decision was made to switch the focus of the company to fibre lasers for industrial machinery.

The company was effectively unknown in the laser market and needed to build a profile and reputation. It also needed to develop a product range that was appropriate for the market. The collaboration with Dr Bill O'Neill at the University of Cambridge, through the IMRC, gave the company access to respected scientists in the laser industry and to resources to embark on an ambitious research project. This signalled its intent to be a serious player in the market.

The IMRC project involved the two parties working together to specify and support the development of a prototype 1KW 'high brightness' fibre laser. At this time, fibre lasers did not generally exceed 20-

[5] http://www.optoiq.com/index/photonics-technologies-applications/lfw-display/lfw-article-display/8943496128/articles/optoiq2/photonics-technologies/news/business-news/2010/5/New-laser-report-from-Strategies-Unlimited-sees-9-percent-market-growth-for-2010.html

30W so it was a very challenging and ambitious project to design a laser with 1KW power. This type of high power laser represents a step change in design, operation and performance. It offers greater beam quality, leading to a greater control over spot size. It is also capable of longer focal lengths meaning the laser can be mounted further away from the object it is working on, making it easier to design into high throughput manufacturing lines.

The research project helped SPI Lasers to launch a new range of high power fibre lasers (up to 200W) from 2006. The product range was upgraded to up to 400W from 2008. The company is currently working on launching a 1KW commercial product. High power fibre lasers are one of two main product lines now offered by the company and help to distinguish it from most of the other competition in the market which still operates at the lower power end.

Assessment of Economic Impact

The economic impact of the project can be assessed as follows:

- Supporting the growth of a UK high-tech SME
- Potential to catalyse new process and product development in other sectors.

Supporting the Growth of a UK High-Tech SME

When the IMRC started to work with SPI Lasers in 2003, it had been through considerable turmoil and had downsized its workforce considerably. Since that time the company has grown substantially to become the No 2 player in the global fibre laser market. Its success led to it being acquired in 2008 by the world's largest industrial laser manufacturer – the German company TRUMPF. Turnover was in excess of £14 million last year and the company now employs approximately 210 people in Southampton which is where it has its main office and production base (a small number of additional sales staff are based overseas). The company is confident about its growth prospects and, depending on the health of the global economy, is expecting year-on-year doubling of turnover for the next few years. It is currently seeking new business space in Southampton to respond to this growth.

The Cambridge IMRC is not directly responsible for the success of SPI Lasers but it has played a significant role in the development of the company. Interestingly, SPI Lasers highlight not only the technical knowledge gained through the collaboration which helped them to launch a new range of high power lasers, but the credibility and profile they gained from working with well known and respected laser scientists at Cambridge University. This was vital in helping the company to break into the laser market where they were unknown. Dr Malcolm Varnham, Vice President of Intellectual Property at SPI Lasers comments:

"The collaboration with the Cambridge IMRC through Dr Bill O'Neill was important in driving forward product development and vital in helping us to establish credibility and presence in a completely different market place to where we started."

Potential to Catalyse New Process and Product Development in Other Sectors

The research project also helped the Cambridge IMRC to establish a world leading position in fibre laser systems research. On-going research is being undertaken to explore new applications for fibre lasers which may catalyse new process and product development in the future, but it is too early to quantify the economic impact of this as yet.

Position without IMRC Funding

In this case, a significant investment in R&D was required to achieve the step change in fibre laser performance that SPI Lasers wanted to achieve. This was beyond the company's resources at the time and as the outcome of the research was highly uncertain, it would have been difficult to secure the required backing from investors. It is possible that resources would have been found as the company became more established, but IMRC accelerated the research and helped SPI Lasers to secure 'early mover' advantage and establish a market leading position in high power fibre lasers.

Consultees

The following people were consulted and reviewed a draft of the case study:

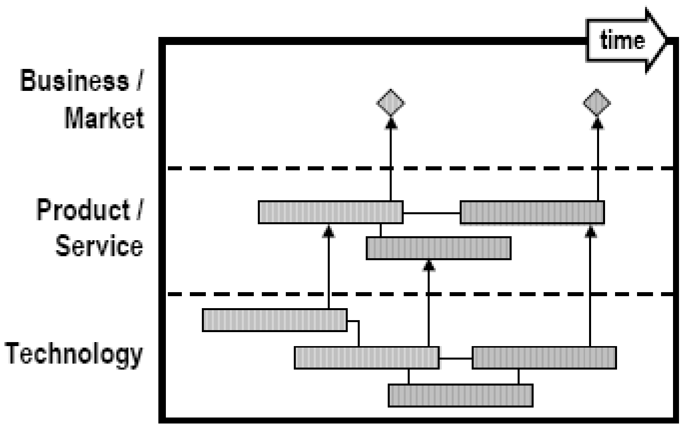
- Dr Bill O'Neill – IMRC, Cambridge IfM
- Dr Malcolm Varnham – Vice-President of Intellectual Property, SPI Lasers

Case Study 3: Strategic Technology Roadmapping

Key Facts	
Time Period	2002-2006
IMRC Funding	£346,000
Other Funding	£92,000
Collaborator(s)	A range of companies and organisations
IMRC Research Theme	Technology Management
Research Output	The output from the research is the S-Plan process – a practical management tool for developing technology (and research) strategies at a business and sectoral level.
Pathway to Economic Impact	**Via in-house publications, training and consultancy services**
Actual Economic Impact	**Influencing the allocation of public research funding.** The Foresight Vehicle Technology Roadmap is part of a strategic framework guiding public and private funded research in the automotive sector. **Assisting companies and other organisations to plan and manage their technology / research functions more effectively.** The IfM (via either its academic or commercial out-reach staff) has undertaken over 200 roadmapping development projects with various businesses / institutions and trained over 750 people since 2005.
Potential Economic Impacts	N / A
Sector Focus	Cross-sectoral

Context

Roadmapping uses a graphical approach to visualise an entire strategy on a page. A technology roadmap can take various forms but generally comprises a time-based chart, divided into a number of layers (see schematic chart below). The idea is to enable linkages to be made in a graphical format between technology drivers and business / market drivers to inform product / strategy development.



The IfM developed the **'T-Plan process'** for technology roadmapping – focussing on strategy for **new product development** – before the establishment of the IMRC with EPSRC responsive mode funding. The IfM was keen to explore further applications for technology roadmapping. In particular, to look at how it could be used at a more strategic level to develop **technology / research strategies** for companies and business sectors. IMRC funding enabled the research to be continued to achieve this goal. The output is a new **‘S-Plan’ process’**.

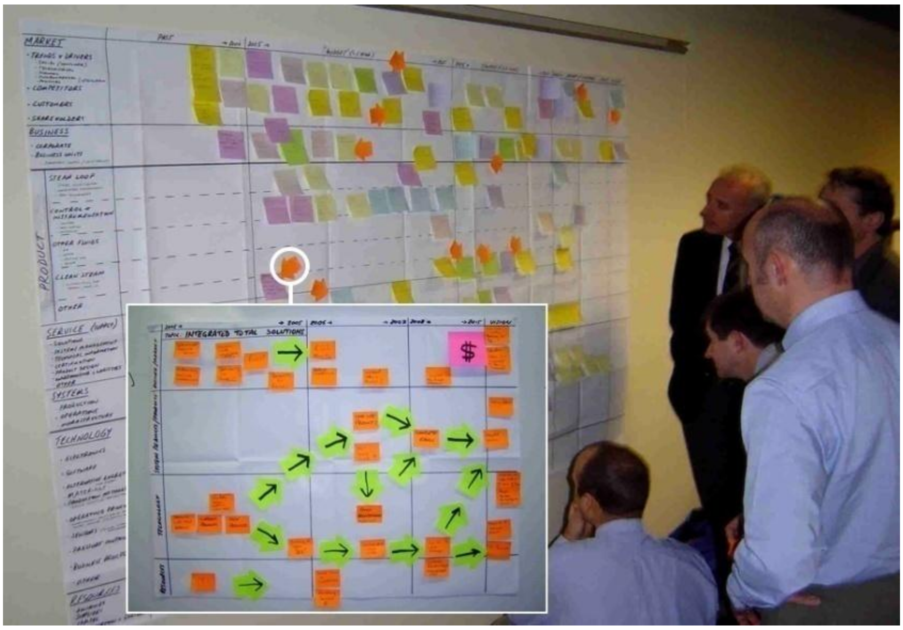
The IMRC Project

The S-Plan process was developed (mainly) through two IMRC funded projects where researchers worked with companies and other organisations to develop the S-Plan tools. The method can be applied at the business unit, corporate, sector or policy level. The standard S-Plan workshop agenda described below is for one day – the most common format. Longer workshops or series of workshops may be required for corporate and sector applications, depending on the scope and complexity involved. The workshop format is designed for 15-25 participants.

The one day format typically involves the following steps:

- **Strategic landscape** – the roadmap framework is used to capture perspectives from all participants (landscape) and to identify and prioritise strategic topics for further exploration.
- **Topic exploration** – in small groups, the roadmap framework is used to articulate the nature of the topics (issues, options or opportunities) and to map how they could be achieved.
- **Review** – topics are presented to all participants for discussion, to agree which to take forward and how to do so.

The S-Plan process was developed through IfM researchers working with a range of companies and organisations to refine the methodology and to develop staff capacity within the IfM to apply the process more widely in the future.



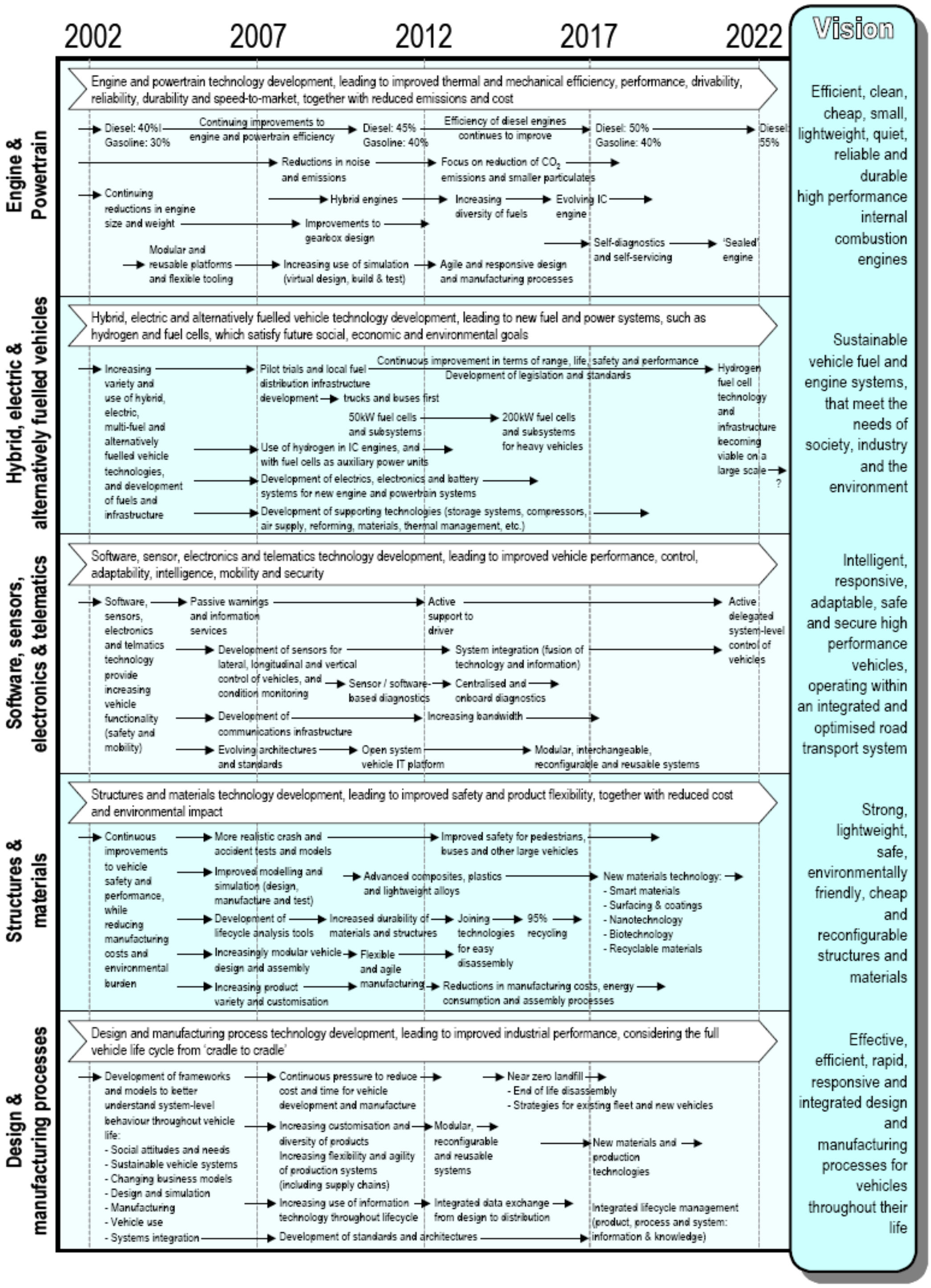
Typical S-Plan workshop activities showing strategic landscape and topic identification roadmap

One of the organisations the IfM worked with to develop the S-Plan process was the **Society of Motor Manufacturers and Traders (SMMT)**. The background to the collaboration goes back to the former DTI LINK programme. There was a feeling among the automotive industry that LINK funding was not going to the right people and projects. Industry felt there were too many academic-led projects which were not reflecting industry priorities. This led to the establishment of Foresight Vehicle, a collaboration between industry, academia and Government to identify technologies and associated research requirements for sustainable road transport. The intention was that future LINK funding should take account of the technology and research priorities identified through this process.

However, the automotive sector is large, wide-ranging and complicated. No one knew quite where to begin in identifying technology and research priorities across an entire sector. There was an awareness of work on technology roadmapping at Cambridge and the IfM was contacted to see if it could assist with a sector roadmapping exercise. This request fitted well with the IfM's desire at the time to elevate technology roadmapping to a more strategic level. Thus, the IfM facilitated the first Foresight Vehicle Technology Roadmap which was published in 2002.
The exercise brought together more than 130 experts from across the road transport sector. It was much larger than a typical S-Plan process involving 10 workshops. The goal was to use the roadmap structure to capture and share views about how road vehicle markets, products, systems and technologies might evolve over the next 20 years and to use this information to identify key research challenges for the next 20 years.

The roadmap framework was first used to summarise information on market trends and road transport targets in a graphical format. Then the roadmap framework was used to summarise information on key topic areas. From this, key research challenges relating to the each of the key topic areas were identified.

An Example of an Output from the Foresight Vehicle Technology Roadmapping Process



Source: Foresight Vehicle Technology Roadmap Version 1.0 2002

The SMMT updated the Foresight Vehicle Technology Roadmap in 2004 (again with input from the Cambridge IfM) and in 2009 (when it managed the process itself).

It is important to stress that this is just one example of how IfM researchers developed the S-Plan process. The researchers worked with many other companies and organisations over this period as well.

The output from the research is the S-Plan process – a practical management tool for developing technology (and research) strategies at a business and sectoral level. The S-Plan process can now be accessed in three ways:

- Practitioner information – information for practitioners on implementing the process is available in a new IfM publication – *Roadmapping for Strategy and Innovation – Aligning Technology and Markets in a Dynamic World* (August 2010).
- Training – the IfM runs training courses on technology roadmapping.
- Consultancy – the IfM has a commercial out-reach arm (IfM Education and Consultancy Services) that uses IfM academic expertise to help businesses and other organisations with particular issues. One of the services offered is technology roadmapping.

Assessment of Economic Impact

The impact of the project can be assessed as follows:

- Influencing the allocation of public research funding
- Assisting companies and other organisations to plan and manage their technology / research functions more effectively.

Influencing the Allocation of Research Funding

The Foresight Vehicle Technology Roadmap undertaken for the SMMT was used to influence LINK (and other public) funding for road transport research. It was a key element in the development of a strategic framework which helped to identify priorities for research funding. It meant there was a better fit between the research base and the needs of industry and policymakers. In addition, it also had an influence on research spending within the automotive industry itself according to the SMMT.

The LINK programme has been taken over by the Technology Strategy Board (TSB) which continues to support automotive research through its collaborative R&D and innovation platform programmes. Since 2007, the TSB has approved around 80-90 projects, and committed around £100 million, to research on low carbon vehicles.

The TSB funded the third revision of the Foresight Vehicle Technology Roadmap in 2009 as part of the process of putting in place a strategic framework for allocating research funding in this area from 2010-2020. At around the same time, BIS established an Automotive Innovation Growth Team (which has since developed into the Automotive Council) to bring industry representatives together to identify key priorities for the future (looking not just at research requirements but issues such as skills, manufacturing and so on). The high level roadmap which emerged from this exercise in 2009 has become the main strategic framework for allocating research funding in the sector. However, TSB believes the roadmapping framework developed at the Cambridge IfM via the IMRC laid the foundations for this by instigating the use of technology roadmapping and collaborative working on technology strategies in the sector.

Assisting Companies and Other Organisations to Plan and Manage their Technology / Research Functions More Effectively

Many other companies, and organisations, have used the S-Plan process to improve the way in which technology and research functions are organised in their companies / institutions:

- **Training**: The IfM runs about five training courses per year with 20-25 participants on each course. This means it has delivered technology roadmapping training to more than 750 professional staff since 2005. Knowledge transfer will continue through this channel in the future.

- **Consultancy**: The IfM (via either its academic or commercial out-reach staff) has been involved in over 200 roadmapping development projects working with organisations such as Airbus, BAE Systems, GKN and Crown.

Position without IMRC Funding

There was a need for underpinning IMRC investment to develop the S-Plan process because the scale of the investment needed to develop the tools was greater than the likely benefits for any individual company / organisation. Subsequently, industry and other organisations are paying to use IfM expertise in this area through training and consultancy services.

Consultees

The following people were consulted and reviewed a draft of the case study:

- Mr David Probert – IMRC, Cambridge IfM

- Dr Rob Phaal – IMRC, Cambridge IfM

- Mr Pat Selwood – formerly responsible for Vehicle Foresight within the Society of Motor Manufacturers and Traders (awaiting verification)

- Andrew Everett – Head of Transport Research, TSB.